The western black-legged tick, *Ixodes pacificus*, in the Sutter Buttes

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ABSTRACT: The western black-legged tick, *Ixodes pacificus*, was collected from Huff Canyon in the Sutter Buttes in north central California, Sutter County. The Sutter Buttes are within the Sacramento Valley and outside the normal distribution of *I. pacificus* in California. Adult *I. pacificus* were collected via flagging as they quested along deer trails; subadult life stages were collected from three species of lizard, *Elgaria multicarinata*, *Sceloporus occidentalis*, and *S. graciosus*. Adult ticks were tested for the presence of spirochetes using the standard IFA with a monoclonal antibody specific for OSP A. Of the ticks tested, 3.3% were identified as positive for the presence of the spirochete *Borrelia burgdorferi*. These results present the first published account of *Ixodes pacificus* as well as the first detection of *B. burgdorferi* in the Sutter Buttes, Sutter County, California.


INTRODUCTION

The western black-legged tick, *Ixodes pacificus* Cooley and Kohls, is the most commonly encountered *Ixodes* species in California (Furman and Loomis 1984). *I. pacificus* parasitizes a wide variety of hosts during its three year, three-host life cycle that includes reptiles, birds and mammals (Padgett and Lane 2001). The distribution of *I. pacificus* in California is predominately within the Coast Range, the northern Cascade Range, and the Sierra Nevada (Arthur and Snow 1968, Kain et al. 1997). Isolated populations of *I. pacificus* have been identified in Utah and Arizona (Allred et al. 1960, Olsen et al. 1992). In California, the great Central Valley, i.e., the Sacramento and San Joaquin Valleys, has inhospitable habitats for *I. pacificus* and geographically separates the population into western and eastern. Allozyme analysis of *I. pacificus* populations, including the isolated populations, shows little genetic differences indicating a high rate of gene flow (Kain et al. 1997).

The Sutter Buttes are a small, circular volcanic range (10mi/16km radius) that exists in the center of the Sacramento Valley floor. This mountain range rises from the valley floor with a change in elevation from 50ft/15m at the valley floor to 2,117ft/645m at the top of the South Butte. The Sutter Buttes are in the Sacramento Valley centrally positioned with the foothills of the Sierra Nevada and Coast Range 45 and 40 miles to the east and west, respectively (Williams and Curtis 1977). The surrounding valley floor historically flooded annually and supported riparian, tule and cattail wetland and open grassland habitat. Today this area consists largely of flood control levees and agricultural lands. The Sutter Buttes habitat is varied depending upon the local topography and aspect. Much of the area consists of open exposed grasslands, while the deeper canyons and some portions of north and east facing slopes support habitat similar to that inhabited by *I. pacificus* elsewhere in California.

MATERIALS AND METHODS

Collection site

A tick survey of the Sutter Buttes was conducted in November of 1998 that identified the existence of adults of *I. pacificus* in shaded oak habitat within canyons and in oak forests on north and east facing slopes. One such canyon, Huff Canyon, is located below North Butte in the Sutter Buttes, Sutter County (latitude 39° 13’ longitude 121° 47’). The site is seasonally mesic, well shaded, with oak leaf litter. The principal vegetation in Huff Canyon consists of blue oak, *Quercus douglasii*, interior live oak, *Q. wislizenii*, scrub oak, *Q. dumosa*, oracle oak, *Q. douglasii* X *Q. kelloggii*, poison oak, *Toxicodendron diversilobum*, large manzanita, *Arctostaphylos manzanita*, and California laurel, *Umbellularia californica*.
Huff Canyon is populated by the coastal race of black-tailed deer, *Odocoileus hemionus columbiana*. Other observed mammals included the coyote, *Canis latrans*, deer mouse, *Peromyscus maniculatus*, and California ground squirrel, *Spermophilus beecheyi*. A variety of resident and migratory birds utilize the canyon.

**Collection of ticks**

Host-seeking adults of *I. pacificus* were collected diurnally from grass blades overhanging deer trails that cross the canyon, either using the standard 1m² white flannel flag or by hand. Efforts to obtain ticks varied but consisted of two persons flagging for approximately two hours on one day each month. Adult ticks were collected in November and December during a three-year period from 1998 to 2000. Adult ticks were separated by gender and stored in vials within humidity chambers until dissection.

**Collection of lizards**

Ten western fence lizards, *Sceloporus occidentalis*, four sagebrush lizards, *S. gracious*, one southern alligator lizard, *Elgaria multicarinata*, and one western skink, *Eumeces skiltonianus* were collected by noosing or by hand during spring and summer 1998 to 2000. Each lizard was carefully inspected for subadult ticks using a 10X hand lens. All ticks found on the lizards were removed with forceps and preserved for identification using taxonomic keys (Webb et al 1990, Durden and Keirans 1996).

**Detection of spirochetes**

Tissue smears from the midgut diverticula of host-seeking adult *I. pacificus* were tested for spirochetes by indirect immunofluorescence using a fluorescein isothiocyanate-labeled goat anti-mouse conjugate (Sigma, St. Louis, MO) and the H5332 anti-*B. burgdorferi* monoclonal antibody prepared against Osp A (U. Texas, San Antonio). Each smear was fixed with cold (4°C) acetone for 10 minutes, stained with the antibody for 60 minutes, rinsed with phosphate-buffered saline (PBS), stained with the conjugate for 30 minutes, rinsed again with PBS, and examined for spirochetes using a fluorescent microscope. Tick smears were examined independently by the Laboratory staff of the Sacramento-Yolo MVCD and by the staff at the Placer County Public Health Laboratory with agreement on negative and positive determinations.

**RESULTS**

A total of 89 host-seeking adult *I. pacificus* was collected from Huff Canyon during November and December in 1998, 1999 and 2000. The total sample consisted of 38 female and 51 male ticks. Sixty-four ticks were collected in 1998, 15 were collected in 1999 and 10 were collected in 2000. In total, 3 (3.3%) ticks, two female and one male, were found positive for *B. burgdorferi*. None of the ticks collected in 1998 were positive, two female ticks were positive from the 1999 collection and one male tick was positive in the 2000 collection. Adult ticks could not be collected during the months of April and May in Huff Canyon.

A total of 16 lizards from four species was captured in Huff Canyon and on North Butte of the Sutter Buttes. The mean abundance of *I. pacificus* larvae and nymphs on *S. occidentalis* (n=10) from the Sutter Buttes was 3.70 (range, 1-11) and 1.0, respectively. The mean abundance of *I. pacificus* larvae on *S. graciosus* (n=4) was 1.25 (range, 0-4). The number of *I. pacificus* larvae on *E. multicarinata* (n = 1) was nine. No ticks were found on *E. skiltonianus* (n = 1). The total mean abundance of *I. pacificus* larvae and nymphs on all lizards was 3.12 (range, 0-11); only one nymph was collected. Larval ticks were collected from lizards during 3 sample trips in April, May and November. The one nymph was collected in May. All collected ticks were identified as *I. pacificus*.

**DISCUSSION**

Our identification and report of *I. pacificus* in the Sutter Buttes represents the first published account of this tick in the buttes and in Sutter County. It is evident that the population is well established because we found all life stages over a three-season period. The few individuals of *I. pacificus* collected over the sample period may indicate a rather small population within a fairly narrow habitat and season relatively to other sites in California. Adult *I. pacificus* were not collected in Huff Canyon during the months of April and May when they are normally active throughout their known range. This apparent adaptation to a narrower activity period may be due to the short wet winters, early spring drying, and summer and fall drought experience in the Sutter Buttes.

Larvae and one nymph of *I. pacificus* were collected from lizards during the drought periods when adults could not be detected. *I. pacificus* larvae were collected from lizards in November well beyond the usual period of host-seeking activity for this stage. Research conducted in northwestern California demonstrated that after hatching in early summer larvae enter diapause until the following spring (Padgett and Lane 2001). Subadult stages of *I. pacificus* have demonstrated the ability to remain attached to lizard hosts for extended periods of time at least as long as 37 to 44 days for larvae and...
nymphs respectively (Wright et al. 1998). Larvae on lizards during November in the Sutter Buttes may reflect an early emergence from diapause or perhaps posthatching, host-seeking, and sustained attachment on their lizard host. Also, it is possible that due to the annual extended drought in the Sutter Buttes, the *I. pacificus* subadult population has adapted to remain attached to host lizards for long periods through the dry season to effectively avoid desiccation.

The mule deer *Odocoileus hemionus* living on the Sutter Buttes are the subspecies *O. h. columbianus* that are from the Coast Range, and not *O. h. californicus* associated with the Sierra Nevada (Ingles 1965). It is therefore a good supposition that some *I. pacificus* arrived in the Sutter Buttes from the coast with *O. h. columbianus* when movement by deer across the valley was less difficult. Today, movement of deer to and from the Sutter Buttes is more difficult due to extensive agricultural and urban development and the associated interstate and highway road network surrounding the buttes in the Sacramento valley. If deer are the only means of transport for *I. pacificus* to the Sutter Buttes, then the population may truly be isolated today.

The presence of *B. burgdorferi* spirochetes in three of the adult *I. pacificus* collected during two of three sample seasons indicates low infection proportions and perhaps an infrequent existence of the spirochete in the population. This may be due to the absence of the principal *B. burgdorferi* reservoirs, the dusky-footed woodrat and the California kangaroo rat in the Sutter Buttes (Brown and Lane 1996). The presence of the spirochete over two seasons may indicate a low level of maintenance, perhaps by *Peromyscus truei* or *P. maniculatus* that have been established as reservoirs in the laboratory and field (Rand et al. 1993, Peavey and Lane 1995). The use of our monoclonal antibody to detect *B. burgdorferi* does not identify the genospecies of the Sutter Butte spirochete. As there are a variety of *Borrelia* genomic groups in California (Postic et al. 1998) and since this may be an isolated population, further work to obtain DNA characterization is clearly indicated.

The presence of a population of *I. pacificus* on the Sutter Buttes is interesting because the surrounding inhospitable habitat, little or no deer immigration, low rodent diversity, and distinctive relict forms all suggest isolation. If the population is truly isolated this may stimulate the evolution of new behavioral adaptations and host parasitism in *I. pacificus*. The evidence of a spirochete detected by our monoclonal antibody in an apparently isolated *I. pacificus* population is also interesting because it may represent an undescribed genospecies and/or non-rodent reservoir hosts as observed in other isolated island sites (Olsen et al. 1993).

On the other hand, the Sutter Buttes *I. pacificus* population may not be totally isolated. Evidence exists that migratory birds may be important hosts for subadult stages of *I. pacificus* in California (Manweiler et al. 1990, Wright et al. 2000, Slowik and Lane 2001). *I. pacificus* infested migratory birds utilizing the Sutter Buttes could annually transport new members to the population and carry away others. In this scenario, we would expect to find no significant genetic divergence between the Sutter Buttes *I. pacificus* population and the larger core population. Finally, birds could also transport *B. burgdorferi* infected ticks to the Sutter Buttes or may even contribute to some degree as reservoirs themselves. The insular nature of the Sutter Buttes makes it the ideal location to investigate these questions and others. Our observations that an *I. pacificus* population exists on the Sutter Buttes indicates that given suitable habitat and hosts this tick can persist in isolated locations. Our detection of a *Borrelia* spirochete within the *I. pacificus* population over two seasons argues that a maintenance host likely exists other than the principal reservoirs.

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